Absorption of gamma rays in blazars by "disky" BLR

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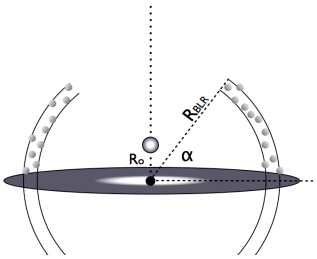
☞ Absorption of gamma rays (*E>10* GeV) through the pair production reaction is expected to be important inside the BLR of FSRQ (e.g. Liu & Bai 2006). Current models for absorption generally assume a spherical (possibly stratified) BLR.

☞ We investigate the effect of the BLR geometry on the opacity, extending a previous study (Tavecchio & Mazin 2009) to the possibility that the BLR is disk-like or "flat" (e.g. Decarli et al. 2011).



Sketch of the **geometry** adopted for the calculation of the optical depth. Gamma rays are produced in the jet at an height R_o above the central black hole and travel into the radiation field of the BLR, characterized by aperture α and radius R_{BLR}. The accretion disc illuminates the clouds whose re-emitted spectrum is calculated using the photoionization code CLOUDY (Ferland et al. 1998, Tavecchio & Ghisellini 2008).

Model parameters:

Disc luminosity, L_{disc}
BLR aperture angle α
Initial distance R_o
The BLR radius R_{BLR} is set by (Ghisellini & Tavecchio 2009)
Covering factor fixed to 0.1

$$R_{\rm BLR} = 10^{17}\left(\frac{L_{\rm disc}}{10^{45}{\rm erg\,s^{-1}}}\right)^{0.5}\ {\rm cm}$$

➥ **The optical depth** is:

$$\tau(E) = \int_{R_o}^{R_{\rm BLR}} \int\int n(\nu,\Omega,l)\sigma_{\gamma\gamma}(E,\nu,\Omega)(1-\mu)d\Omega d\nu dl$$

- E is the gamma ray energy
- ν is the target photon frequency
- σ is the γγ → e± cross-section
- n is the number density of the BLR radiation at each location of the photon path, l
- μ=cosΘ, Θ being the collision angle

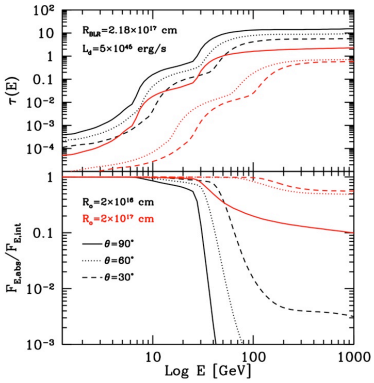
Results:

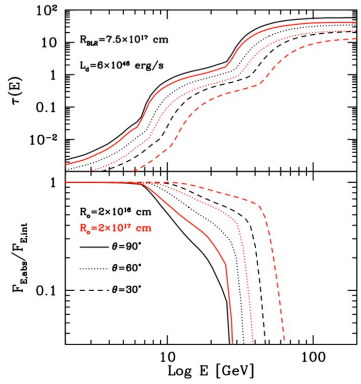
✔ The two plots show the optical depth τ as a function of the gamma-ray energy (upper panel) for a low luminosity (left) and a high luminosity (right) accretion disk for different values of α and R_o.
The lower panel show the corresponding ratio between intrinsic and absorbed spectrum.

✔ For high disk luminosity the BLR is strongly opaque for any aperture angle at energies above few tens of GeV.

✔ Clearly visible are spectral breaks around 10 and 30 GeV resulting from H and HeII Lyman α lines (Poutanen & Stern 2010).

✔ As expected for low luminosity discs the BLR absorption is less important: however, transparency is reached only if the injection of gamma rays occurs outside the BLR effective radius.





Concluding: even if the BLR is characterized by a "flat" geometry its radiation field severely absorbs gamma rays above few tens of GeV within the regions with R<R_{BLR}

References:

Decarli et al. 2011, MNRAS, in press (arXiv:1011.5879) - Ferland et al. 1998, PASP, 110, 761 - Ghisellini & Tavecchio 2009, MNRAS, 397, 985 - Liu & Bai 2006 ,ApJ, 653, 1089 - Poutanen & Stern 2010, ApJ, 717, L118 - Tavecchio & Ghisellini 2008, MNRAS, 386, 945 - Tavecchio & Mazin 2009, MNRAS, 392, L40